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THE TOBACCO SPLITWORM.

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Of Southern Field Crop Insect Investigations.

INTRODUCTION.

The following account of the tobacco splitworm (*Phthorimaea operculella* Zeller), although not complete, contains data not heretofore published. The life history notes, description of stages, etc., were made by the junior writer. Credit is due the senior writer for the observations made in Florida and for the recommendations under the heading: "Remedial measures."

In California this insect is a serious potato pest, and Dr. F. H. Chittenden [1] reports that in 1912 two growers at El Monte, Cal., lost $90,000 and $70,000, respectively, on the crop of that year. Although quite generally distributed over the Southern States, this insect has caused serious loss to tobacco growers in only one locality, viz., Dade City, Fla. The injury at that place was severe in 1906, more severe in 1907, and culminated in 1908 in a conservatively estimated loss of $150 per acre—a loss totaling $12,000 for the 80 acres of shade-grown tobacco. The injury since 1908 has been very light, due in part to the early planting and in part to the very careful and very thorough remedial measures employed.

The variation in food habits, which is noted later, had created the suspicion that the form working upon potatoes might be specifically distinct from the one attacking tobacco. During the summer of 1913 experiments were conducted to determine this point.

EXPERIMENTS ON THE SPECIFIC STATUS OF THE TWO FORMS.

The potato-tuber moths used in these experiments were of the habitual potato-feeding type from Whittier, Cal., kindly furnished by Mr. J. E. Graf. The splitworm moths were of the habitual tobacco-feeding type from Florida, North Carolina, and Virginia.

[1] Chittenden, F. H., 1912. The potato-tuber moth., A preliminary account. (*Phthorimaea operculella* Zell.). U. S. Dept. Agr., Bur. Ent., Circ. 162, p. 2. Chittenden, F. H., 1913. The potato-tuber moth. U. S. Dept. Agr., Farmers' Bul. 557, p. 2.

Larvæ of the potato-tuber moth were reared on potato tubers and on the foliage of *Solanum carolinense*, eggplant, *Physalis* sp., *Datura stramonium* ("jimsonweed"), and tobacco; they also mined the leaves of *Solanum nigrum* until the plant died. Larvæ of the tobacco splitworm moth were reared on potato tubers and on the foliage of *Solanum carolinense*, eggplant, *Physalis* sp., *Physalodes physalodes*, *Datura stramonium*, and tobacco. There was no perceptible difference in the period of development, in habits, or in behavior of the two forms on a given food plant that could be ascribed to the different origins of the individuals. A male potato-tuber moth of the habitual potato-feeding type and a female splitworm moth of the habitual tobacco-feeding type, reared from isolated pupæ and caged together, produced larvæ that reached maturity upon tobacco.

The earliest stages of the two types show no appreciable differences except in the case of the larva, and here the differences, excepting size, are entirely colorational. The larva on potato is larger, grayish, and has the mesothorax and metathorax pinkish, while the habitual tobacco feeder is green and has the mesothorax and metathorax deep maroon. By reversing the two food plants the larvæ can be made to approach each other in coloration, but even after two generations on tobacco the habitual potato feeder is less green and has the thorax distinctly paler than the habitual tobacco feeder; also, the coloration of the latter type persists when reared upon potato tubers. The larvæ of the crossed moths were intermediate in coloration between the two types just discussed.

The rather persistent color variation noted in the two larval types under discussion, while probably of sufficient constancy to warrant a varietal separation, is not, the writers believe, of sufficient importance to justify a specific separation.

Potato-tuber moths reared from potato are usually somewhat larger than splitworm moths reared from tobacco. This difference disappears when the potato-tuber moth is reared on other plants. Potato-tuber moths reared from potato tubers, *Physalis* sp., *Solanum carolinense*, tobacco, and *Datura stramonium*, and splitworm moths reared from tobacco, potato tubers, and *Physalis* sp., were submitted to Mr. August Busck, who reported that he could find no specific differences.

DISTRIBUTION.

In the United States the species occurs in California and southward from a line connecting the District of Columbia and Colorado. The definite localities include Tennessee, Virginia, North Carolina, South Carolina, Florida, and Texas. Reports of more northern occurrence are probably due to the shipment of infested potatoes into these

localities. The known range also includes Cuba, Costa Rica, Peru, Hawaii, Australia, Tasmania, New Zealand, Sumatra, Transvaal, Algeria, and southern Europe.

COMMON NAMES.

Phthorimaea operculella when working upon tobacco is known as the tobacco splitworm and the tobacco leaf-miner; when working upon potatoes it is known as the potato-tuber moth and the potato moth.

FOOD PLANTS.

The known food plants of *Phthorimaea operculella* include *Solanum torvum, S. verbascifolium, S. carolinense, S. nigrum*(?), eggplant, potato, tomato, *Physalis peruviana, Physalis* sp., *Physalodes physalodes, Datura stramonium,* and tobacco.

FOOD HABITS.

The larva occurs as a borer and also as a leaf-miner. The former is probably the original habit, examples of which have been observed by Quaintance in the fruit of eggplant, by Kotinsky in tomatoes, and by C. W. Howard and Oliff in the stems of tobacco. Dr. L. R. De Bussy considers this the more common form of injury to tobacco in Sumatra, where the larva forms a gall in the stem. C. W. Howard reports a similar habit of the larva in the Transvaal.[1]

In Cuba and the United States the insect is known on tobacco as a leaf-miner only. A boring tendency is still apparent, however, as noted by Houser, in that the larva usually tunnels the midrib or a vein in addition to mining the membrane of the leaf. In about 50 mines examined by us the larva had also tunneled the midrib or a vein in almost every case.

Only the older tobacco leaves are affected, unless the infestation is very severe; and in these, the lower leaves, grayish, irregular blotches are produced, which later turn brown and become fragile, so that the tobacco is unfit for wrappers. At Clarksville, Tenn., where the infestation is very slight, the larva in most cases begins work in the "ruffles" along the midrib and may afterward migrate and form mines in various parts of the leaf.

In forming its mine the larva begins by spinning a tent of silk between the midrib, or between the vein and the surface of the leaf. Under this protection it soon forms a shelter between the leaf surfaces by consuming the parenchyma. The mined leaf becomes more or less distorted, and this is especially noticeable on leaves,

[1] *Gnorimoschema heliopa* Low causes similar injury to tobacco in India, Ceylon, and Java.

such as those of *Solanum carolinense*, which the larva is more capable of manipulating, but there is no tendency to form a firm, cylindrical, silk-lined tube, as is the case with the blue or bluish-green larva of *Phthorimaea glochinella* Zell., which feeds upon some of the same plants as does *Phthorimaea operculella*.

DESCRIPTION OF STAGES.

THE EGG.

The egg is pale, translucent, yellowish gray, and strongly iridescent; it is oval, 0.45 mm. long, 0.35 mm. broad at the middle, membranous, and without apparent sculpture. The side upon which it is deposited is slightly flattened.

THE LARVA.

The full-grown larva is 7 to 14 mm. long. The head shield is 0.80 to 0.86 mm. broad and fuscous brown. The cervical shield is darker brownish fuscous, with a pale mid-dorsal line, shining, the posterior margin medially straight. The anal shield is brown. The mesothorax and metathorax are deep maroon. The body varies in color through green and gray and is overlaid dorsally with purplish as the larva nears pupation. It is slender, tapering from the mesothorax posteriorly and set closely and uniformly with minute granules each bearing a minute point, the granules of the thorax and the last abdominal segment being the larger. The tubercles and their setæ are inconspicuous, brownish; tubercle II is slightly larger than I. The legs are deep fuscous; the prolegs, green.

The larva which has just emerged is light grayish, with strongly contrasting dark head and cervical shield.

Larvæ which have been reared habitually upon potatoes are of a larger average size than those reared upon tobacco, and the maximums of the foregoing measurements are from potato-feeding larvæ. The larva on potato is more grayish on the body than the tobacco miner and has the mesothorax and metathorax pinkish instead of deep maroon.

THE PUPA.

The pupa is yellowish brown, 5.5 to 7 mm. long and 1.5 to 2 mm. broad; it is broadest through the metathorax, tapering both anteriorly and posteriorly. The head is rather distinct and slightly nodding. The abdomen, excepting the last three segments, is set with very minute spinules; it bears at the tip mid-dorsally a short, curved, erect, pointed horn flanked by about four pairs of long hooked spinules, and ventrally a pair of blunt, rounded lobes beneath which are about four pairs of long hooked spinules. Each abdominal segment is set with a transverse row of spinules near the anterior margin.

As in the case of the larvæ, the pupæ of the habitual potato feeder are larger than those from the habitual tobacco feeder and the maximum measurements in the foregoing description are from potato-reared pupæ.

The adult is a slender, inconspicuous moth with dark grayish wings bearing indefinite yellowish streaks and having an expanse of about 20 mm.

LIFE HISTORY.

At Clarksville, Tenn., the splitworm requires 25 to 30 days in summer for completing its development from egg to adult. Of this time 4 days are spent in the egg stage, 15 to 17 days in the larval stage, and 6 to 9 days in the pupal stage. The length of these stages is considerably affected by temperature, as is indicated in detail in the accompanying tables. By reference to Table III we see that at an average mean temperature of about 81° to 82° F. the minimum pupal period is obtained, and that when the average mean temperature falls below about 68° to 70° F. the pupal period is very greatly lengthened.

Eggs are deposited singly upon the foliage of the host plant. Moths begin to oviposit two or three days after emergence and continue ovipositing for several nights. The largest number of eggs obtained from a single moth was 46, but this probably does not represent the maximum oviposition under normal conditions.

The larva is very active, is capable of prolonged exertion immediately after hatching, and clings very tenaciously to the foliage. The frass is either stored in a particular part of the mine or is cast outside where, in the case of those working upon potato tubers, it forms masses held together by silk. The larva pupates in a slight but somewhat tough cocoon of silk and débris among clods or rubbish at or near the surface of the soil.

TABLE I.—*Length of egg stage of tobacco splitworm.*

Eggs deposited night of—	Eggs hatched night of—	Egg stage.	Average mean temperature.
		Days.	° *F.*
June 15, 1910	June 19, 1910	4	77.3
June 17, 1910	June 21, 1910	4	79.5
June 22, 1910	June 27, 1910	5	80.5
July 3, 1913	July 7, 1913	4	82
July 3, 1913	July 7, 1913	4	82
July 4, 1913	July 8, 1913	4	80.9
July 5, 1913	July 9, 1913	4	79.7
Aug. 5, 1913	Aug. 8, 1913	3	88.6
Aug. 6, 1913	[1]Aug. 10, 1913	3½	88
Aug. 21, 1913	Aug. 25, 1913	4	72.6
Sept. 11, 1913	Sept. 15, 1913	4	81.9
Sept. 12, 1913	Sept. 16, 1913	4	82.4

[1] Forenoon.

TABLE II.—*Length of larval stage of tobacco splitworm.*

Egg hatched night of—	Larva pupated night of—	Larval stage.	Average mean temperature.	Food plant.
		Days.	*° F.*	
June 21, 1910	July 6, 1910	15	78.7	Tobacco.
July 9, 1913	July 25, 1913	16	81.1	Do.
Aug. 25, 1913	Sept. 10, 1913	16	81.2	Do.
Aug. 25, 1913	Sept. 11, 1913	17	81.1	Do.
Sept. 27, 1911	Nov. 3, 1913	37	64.4	Do.

The lengths of the larval stage given above are corroborated by about 25 records giving the combined length of the larval and pupal stages.

TABLE III.—*Length of pupal stage of the tobacco splitworm.*

Number of individuals.	Larva pupated night of—	Moth emerged night of—	Pupal stage.	Average mean temperature.	Food plant of larva.
			Days.	*° F.*	
2	Apr. 21, 1909	May 14, 1909	23	65.1	Tobacco.
4	May 22, 1910	June 5, 1910	14	67—	Do.
1	July 6, 1910	July 14, 1910	8	83.3	Do.
1	July 25, 1913	Aug. 1, 1913	7	85.1	
[1] 3	Aug. 19, 1913	Aug. 28, 1913	9	77.1	Potato.
1	do	do	9	77.1	"Jimsonweed."
1	do	Aug. 29, 1913	10	77.5	Potato.
[1] 1	Aug. 21, 1913	Aug. 30, 1913 [3]	8.5	76.4	Tobacco.
1	Aug. 27, 1911	Sept. 8, 1911	12	76.8	Do.
1	Aug. 31, 1913	Sept. 6, 1913	6	83.7	Do.
2	do	do [3]	5.5	83.7	Do.
1	do	do [4]	6—	83.7	Do.
3	Sept. 1, 1913	Sept. 7, 1913	6	83.7	Do.
1	do	Sept. 8, 1913	7	83.2	Do.
1	Sept. 2, 1913	Sept. 9, 1913	7	81.8	Do.
1	Sept. 3, 1913	do	6	81.4	Do.
1	do [2]	do	7	81.4	Do.
3	do	Sept. 10, 1913	7	81	Do.
2	Sept. 10, 1913	Sept. 23, 1913	13	69	Potato.
1	do	Sept. 24, 1913	14	69.1	Do.
1	Sept. 11, 1913	Sept. 27, 1913	16	68—	Tobacco.
2	Sept. 13, 1913	Sept. 29, 1913	16	67.6	Do.
1	Sept. 27, 1913	Oct. 9, 1913	12	70.4	Do.
1	Sept. 30, 1913	Oct. 15, 1913 [4]	15	68.3	Physalis.
1	Oct. 1, 1913	do [4]	14	68.3	Do.

[1] Reared from moths of the habitual potato-feeding type. [2] Forenoon. [3] 2 p. m. [4] Afternoon.

SEASONAL HISTORY.

Full-grown larvæ have been received from Florida in late April, indicating that oviposition may begin in that region as early as March. Larvæ have not been found at Clarksville, Tenn., earlier than June 3, and moths have emerged in numbers as late as the middle of November. It seems probable that at least six generations are produced in Florida and that about three or four are produced at Clarksville, Tenn. Moths emerged in five cages at Clarksville November 14, 1913, and were still active December 15, 1913, upon which date about an equal number of cages still contained pupæ. These records seem to indicate that the winter is passed in both the pupal and adult stages. No larvæ, so far as known, have entered hibernation successfully.

PARASITES.

Kotinsky[1] records two larval parasites, *Chelonus blackburni* Cam. and *Limnerium polymesiale* Cam. About 25 per cent of the full-grown larvæ of a large shipment of splitworms, sent by Mr. G. A. Runner late in August, 1913, from Kinston, N. C., were parasitized. Several parasitic larvæ emerged from each splitworm which was killed at or just before the emergence of the parasite, and while still in the mine. The parasites spun their cocoons in the mine and sometimes within the larval skin. A single splitworm from which this parasite was reared was included in another large shipment of material sent by Mr. Runner from Appomattox, Va. Larvæ of this parasite which emerged from the host September 1, 1913, pupated September 3, and the adults emerged September 10, giving a pupal stage of seven days.

REMEDIAL MEASURES.

Quaintance[2] recommends the destruction of the larvæ in the mines by pinching, and the destruction of all trash in and around tobacco fields and tobacco barns. Both of these recommendations should be followed. However, in severe infestations it may be necessary to prime off and destroy the leaves infested by the earlier generations. A heavy infestation would ruin the leaves for wrappers, in which case the priming and destruction of the leaves will be a cheaper and more thorough method of destruction, for it will cause the death not only of the larvæ but also of a large number of eggs. This plan was pursued at Dade City, Fla., following the severe infestation of 1908, and with excellent results. Since that year, also, the crop has been transplanted much earlier than was the custom previously, and was matured before the appearance of the most destructive generation of the splitworm. Loss has been very light since 1908.

To summarize the remedial recommendations: (1) Transplant the crop as early as possible, in order to mature it before the appearance of the most destructive generation of the splitworm; (2) when the early infestation is very severe, prime off and destroy the infested leaves; (3) destroy all tobacco stubble as soon as the crop is harvested to prevent the breeding of a hibernating generation; (4) clean up and destroy all trash in and around tobacco fields and tobacco barns; (5) do not follow potatoes by tobacco, for the infestation of tobacco has been more severe in such cases than where a different rotation was followed; (6) grow potatoes as far as possible from tobacco fields.

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[1] Kotinsky, Jacob, 1906. Hawaii. Forester and Agr., v. 3, no. 7, p. 200–201.

[2] Quaintance, A. L., 1898. The tobacco leaf-miner (*Gelechia picipellis* Zett.). Fla. Agr. Exp. Sta., Bul. 48, p. 178–181.